[0042] A process of at least one embodiment herein may provide three dimensional micromagnets for microelectromechanical devices as well as active magnetic material components for use in a variety of information storage devices. An embodiment may provide a means for deposition of ferromagnetic metals as a precursor to forming two-dimensional or three-dimensional silicide contacts in microelectronics. In at least one embodiment provided herein, a process may provide a variety of device geometries formed from partially filling trenches, i.e., horseshoe magnets, or vias, i.e., magnetic cylinders. Trenches and vias may be completely filled and may even provide embedded magnetically isolated structures in nonferrous environments.

[0043] At least one embodiment disclosed herein provides void-free filling of recessed surface features on non-planar conducting surfaces with iron group magnetic materials. Specifically, the addition of certain benzimidazole derivatives to a conventional additive-free nickel plating baths, e.g. Watts bath $NiSO_4$—$NiCl_2$ or sulfamate (SO_3NH_2—) bath may result in a superconformal deposition growth mode which may provide a manufacturable solution to problems associated with bottom-up filling with the overall growth front propagating uniformly across the work piece.

[0044] In at least one embodiment disclosed provides a process for electrodepositing of ferromagnetic materials such as Ni, Co, Fe, and alloys containing combinations thereof into trenches and/or vias in a substrate, such as dielectric substrate containing Si or some other element or compound. The process comprises a modified damascene process wherein the substrate is first etched by processes known in the art to form trenches and/or vias in a surface thereof. This three dimensional structure may then prepared with an adhesive material such as the physical vapor deposition of a thin Ti adhesion layer. An electric conductive seed layer such as Cu is then placed on the surface of the three dimensional structure of trenches and/or vias by processes as known in the art. This prepared substrate is then placed into an electrolytic bath containing at least one ferromagnetic material and at least one heterocyclic benzimidazole derivative such as MBIS. A counter electrode is then placed into the Watts bath and an electrical current is passed between the prepared substrate and the counter electrode. The ferromagnetic material(s) are first preferentially deposited at the bottom corners of the trenches and/or vias and then the three dimensional structure in the substrate material is filled by bottom-up filling. The filled substrate may then be planarized to remove any overburden of the ferromagnetic material(s). The process provides substantially void-free feature filling of submicrometer trenches and/or vias in a dielectric substrate with ferromagnetic materials. The product produced by this process may be a multilevel interconnection having ferromagnetic material (s) in trenches and/or vias with little or no void space within the three dimensional structure.

[0045] In at least one embodiment, the substrate is electrically conductive. Providing an electrically conductive substrate may eliminate the steps of preparing the substrate with an adhesive material and placing an electric conductive seed layer on the surface of the three dimensional structure of trenches and/or vias.

[0046] Examples of at least one embodiment are discussed in two recently published articles. One of such articles is entitled, “Electrodeposition of Ni in Submicrometer Trenches” by S.-K. Kim, J. E. Bonevich, D. Josell, and T. P. Moffat, published in the Journal of The Electrochemical Society 154 (9) D443-D451 (2007), incorporated herein in its entirety. This article discusses the effect of cationic, anionic, and nonionic surfactants on the rate and morphological evolution of nickel electrodeposition. Attention is given to the prospect for void-free filling of submicrometer trenches. Cationic species such as polyethyleneimine (PEI) and cetyltrimethyl-ammonium (CTA+) were shown to yield significant inhibition of nickel deposition. The other article entitled “Magnetic Materials for Three-Dimensional Damascene Metallization: Void-Free Electrodeposition of Ni and $Ni_{70}Fe_{30}$ Using 2-Mercapto-5-benzimidazolesulfonic Acid” by Chang Hwa Lee, John E. Bonevich, Joseph E. Davies, and Thomas P. Moffat, published in the Journal of The Electrochemical Society, 155 (7) D499-D507 (2008), incorporated herein in its entirety. This article discusses superconformal filling of submicrometer trenches with electrodeposited ferromagnetic materials in an electrolyte containing 2-mercapto-5-benzimidazolesulfonic acid (MBIS). The process may offer the ability to build three-dimensional magnetically active structures that may be easily integrated with other state-of-the-art metallization schemes such as the Damascene process.

[0047] In at least one embodiment provided herein, a process for the electrodeposition of nickel, cobalt, iron, and alloys thereof in 3-D structures in a dielectric material is provided. A process of electrodepositing at least one ferromagnetic material into a three dimensional pattern within a dielectric or metallic substrate may comprise providing a dielectric or metallic substrate material having a three dimensional recessed pattern in at least one outer surface thereof. In the case of a dielectric substrate an electrical conductive material is deposited onto the outer surface having the 3-D pattern and within the three dimensional pattern providing a wetting conductive seed layer on the substrate.

[0048] An electrolytic bath is prepared comprising at least one ferromagnetic material and at least one accelerating, inhibiting, or depolarizing additive. The at least one ferromagnetic material has at least one of Ni^{2+}, Co^{2+}, Fe^{2+}, Fe^{3+}, and combinations thereof. The dielectric substrate having the seed layer is placed into the electrolytic bath where the electrolytic bath contacts the at least one outer surface and the three dimensional pattern having a seed layer in the case of a dielectric substrate. A counter electrode is placed into the electrolytic bath and an electrical current is passed through the electrolytic bath between the seed layer on the substrate and the counter electrode. At least a portion of the ferromagnetic material is deposited into at least a portion of the three dimensional pattern wherein the deposited ferromagnetic material is substantially void-free. The electrodeposition step may provide superconformal filling of the 3-D pattern.

[0049] The at least one accelerating, inhibiting, or depolarizing additive may comprise a nitrogen containing compound. Alternatively or additionally, the at least one accelerating, inhibiting, or depolarizing additive may have a compound selected from the group consisting of cationic surfactants, anionic surfactants, nonionic surfactants, heterocyclic benzimidazole derivatives, and combinations thereof. Advantageously, the at least one accelerating, inhibiting, or depolarizing additive may comprise a compound selected from the group consisting of polyethyleneimine, 2-mercapto-5-benzimidazolesulfonic acid, and combinations thereof. Alternatively or additionally, the at least one accelerating, inhibiting, or depolarizing additive comprises polyethyleneimine. Furthermore, the at least one accelerating, inhibiting,